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ALLRecovery – Mobile App for Acute Lymphoblastic Leukemia Education

Yao Jia Zhang
yz5174@rit.edu

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ALLRecovery – Mobile App for Acute Lymphoblastic Leukemia Education

by

Yao Jia Zhang

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Thesis Author: Yao Jia Zhang

Chief Advisor: James Perkins, MS, MFA, CMI

Signature _____

Date _____

Associate Advisor: Glen Hintz, MS

Signature _____

Date _____

Associate Advisor: Angela Punnett, MD, FRCPC

Signature _____

Date _____

Vice Dean, College of Health Sciences and Technology: Richard Doolittle, PhD

Signature _____

Date _____

ABSTRACT

Acute lymphoblastic leukemia (ALL) is a cancer of the bone marrow. Lymphoblasts are unable to mature due to errors in signaling leading to an accumulation of non-functioning lymphoblasts. ALL is one of the most common cancers found in children; with an estimated 6590 new cases in the United States in 2016 (seer.cancer.gov, 2016). When a family finds out that their child has been diagnosed with cancer, it could be a shocking and terrifying experience. Understanding and learning about the nature of the disease can be a helpful method to cope with the fear and anxiety. ALLRecovery is created to present a friendly way to explain the complex medical concepts associated with ALL and its treatment. ALLRecovery is an interactive mobile application designed to teach patients and their families about ALL and the common treatments. The app includes 3 animations that serve as an introduction to the arcade game, RECOVER. RECOVER is a top-down shooter game where the player controls chemotherapy agents to destroy leukemia cells.

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INTRODUCTION

Project Concept

Acute lymphoblastic leukemia (ALL) is one of the most common cancersfound in children (Cooper et al, 2015). Currently, an easily accessible learning aid for a younger audience is not available. Since, the 5-year survival rate for childhood ALL is more than 90% and growing(Cancer.org, 2015), the information given to patients and their family members should be more hopeful. Presenting the concept of ALL as a cartoon and a game is a friendly way to explain the illness and can help patients and their families cope with fear and anxiety. Using the mobile application platform allows easier access to the material.

ALLRecovery is an interactive mobile application designed to teach patients and their families about acute lymphoblastic leukemia and the common treatments. The app includes three animations that serve as an introduction to the arcade game, RECOVER. RECOVER is a top-down shooter game where the player uses chemotherapy to destroy leukemia cells.

Audience

The primary audience of ALLRecovery is patients diagnosed with acute lymphoblastic leukemia. The content is targeted towards children ages 6-12, an age range commonly affected by ALL. The secondary audience will include family members and guardians of the patients, as well as physicians and medical educators who may use the app for teaching purposes.

Goals and Objectives

The primary goal of ALLRecovery is to provide an engaging and interactive method for acute lymphoblastic leukemia education. After viewing the animations and playing the game, the audience will be able to name the major cells and biological structures involved in acute lymphoblastic leukemia, reiterate why ALL is dangerous, explain each stage of ALL and the chemotherapy processes involved with the treatment. The secondary goal of ALLRecovery is to implement realistic representation of biological and cellular structures.

SECTION 1: SCIENTIFIC BACKGROUND

Acute lymphoblastic leukemia (ALL) is a cancer of the bone marrow (Seiter, 2014). It is caused by problems during the development of a specific group of white blood cells called lymphocytes (Seiter, 2014). Immature lymphocytes, known as lymphoblasts, are unable to mature due errors in signalling (Seiter, 2014). These signals also cause lymphoblasts to multiply rapidly but serve no function. As the number of abnormal lymphoblasts increases, there is less space and nutrients for normal blood cells, hence fewer normal blood cells are produced (Seiter, 2014).

Chemotherapy is the most common treatment used to destroy leukemia cells and to prevent further development of ALL(Cancer.org, 2015). Chemotherapy agents target rapidly dividing cells such as the abnormal lymphoblasts. The first phase is called the induction phase, where the goal is to kill as many leukemia cells as possible. If the leukemia cells become less than 5% of the bone marrow mass, the patient is in remission. The second phase is called the consolidation phase. This phase aims to kill any remaining leukemia cells and prevent the spread of leukemia into the brain. A different chemotherapy agent is injected directly into the cerebral spinal fluid, often by the means of a lumbar puncture. The third phase is called the maintenance phase where low doses of chemotherapy are given to the patient to make sure that only healthy cells remain (Truong et al, 2010).

Currently there is not a visual learning aid available for a young audience that is easily accessible and focuses more on learning than entertainment. A similar existing cancer fighting game is Re-MISSION by HopeLab (www.hopelab.org). Re-MISSION contains beautiful 3D graphics and an entertaining game play. Weaknesses of Re-MISSION include accuracy, accessibility and specificity. In Re-MISSION the player is a human character who goes into the body and picks up chemotherapy packs within the human body to destroy cancer cells. This could potentially confuse the audience about the process of chemotherapy. For example, the player may believe that chemotherapy is natural to the human

body and can be activated during treatments. Re-MISSION is also only available on Windows PCs which may be harder to access compared to a mobile device. Lastly, Re-MISSION uses different cancer cells as targets instead of targeting only ALL.

SECTION 2: THE BODY OF WORK

User Centered Design

The original goal of the project was to educate a lay audience about acute lymphoblastic leukemia (ALL). The initial visualizations of the project were planned to look realistic with complicated 3D rendered models to give an accurate representation of the structures involved with ALL. The choice of creating an app arose from the accessibility and mobility of the delivery. Alternate media such as booklets and websites were also considered. The app would contain three animations that explained ALL. The animation topics were:an overview of blood cells and their functions; how ALL develops with relation to blood cells;and the chemotherapy treatments for ALL.

After several discussions with thesis committee members, the audience of this project was narrowed down to children ages 6-12, the age range that represents a majority of the patients diagnosed with ALL. It was decided that it would be most effective if children and their guardians could use the app collectively to learn about the illness as a group and further bring family and friends together during this difficult time. The topics of the three animations were unchanged and a game was added to the app. The animations would serve as an introduction to the game while the game would provide an applicable chemotherapy scenario as well as minor entertainment for the children. The style of the project also shifted from a 3D realistic look to a 2D cartoon look.

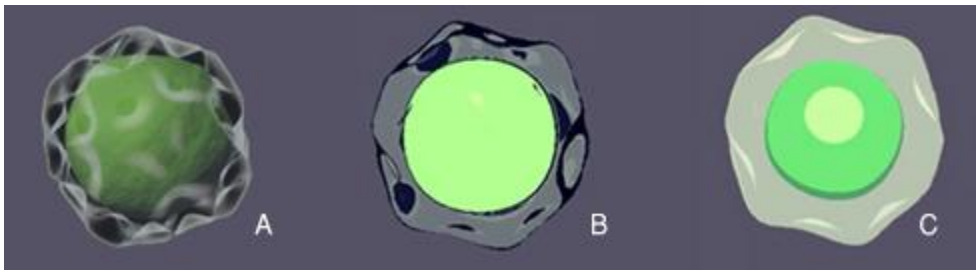


Figure 1.Project style development.

Referring to figure 1, cellA was the original, 3D realistic style. Cells B and C were considered when the project changed to a 2D cartoon look. Ultimately, the style of cell C was chosen as the style of the whole project. The rendering of these cells was completed using Autodesk Maya. The decision of using Maya was due to the program's capability to render cartoon shadings which looked 2D while adding motion with correct perspective and depth.

After the audience of the project was changed, a decision was made to include human characters to further capture the interest of the younger audience. Three characters were developed to act as narrators of the three animations. The characters took on the form of secret agents as a play on the term "chemotherapy agents"; the characters were named Agent Vincristine, Agent Methotrexate and Agent Mercaptopurine. Vincristine, Methotrexate and Mercaptopurine are a few of the most common chemotherapy agents used in the treatment of ALL(Truong et al, 2010).Abbreviated names of the chemotherapy drugs (VCR, MTX, MP) were also introduced to provide an easier pronunciation for the audience in case these characters were referred to in conversation. Using these names and characters allow the audience to be comfortable with these names and the idea of chemotherapy. The characters are a mix of different genders, skin tones and hairstyles to portray dramatic, energetic, but still relatable mentors.

Animation

The animations were written in a children friendly language with simple sentence structure, but still included important scientific terminology. This allows the audience to distinguish the important terms associated with ALL and the treatment for the disease.

Game

The game was created to enforce the concept that chemotherapy is used to destroy leukemia cells all over the body. Ideally, chemotherapy would only affect cancer cells and not the healthy blood cells.

Hence, this concept was portrayed in the game so the normal blood cells were unaffected by the chemotherapy. Healthy foods are designed into the game to give the player extra points, to encourage to patients to consume healthy foods when undergoing chemotherapy treatments. Additionally, "game over" was not applied to the game due to the negative representation that it may bring to the viewers. Therefore, there are no hazards in the game to allow the player to lose.

The game begins on a title screen which introduces the objectives and the gameplay. The game contains three levels that vaguely represent the three stages of chemotherapy. The level 1 or induction phase of the game is located in a blood stream. Chemotherapy is reloaded quickly during this level to represent the strong start to the treatment. The fast reload also makes the level easier for the player to reach the number of points needed to move onto the next level. Level 2 or the consolidation phase is located in the cerebral spinal fluid of the spinal cord as the spinal cord is a main target during this phase. Level 3 or the maintenance phase moves back to the blood stream. Chemotherapy reload is significantly slower to increase the difficulty of the game. The game ends with a congratulatory message to the player.

App Design

The app installation file was generated in Unity. Additional screens such as the loading screen and the start and exit screens were also added to provide feedback to the user based on touch commends. Pause and mute buttons were added to allow the viewer to control the music and the pace of the game. The animations were added to the app as thumbnails that linked to the videos that are hosted on Youtube.

Visual Design

Assets and Animations

Once the style was confirmed, modeling and shading in Maya continued and a script and storyboards were produced. The storyboards were created using Adobe Illustrator to match the toonshader

generated in Maya. Illustrator was the program of choice because adjustments and revisions can be made easily. The vector assets created in Illustrator can also be used in the animations when only one single view and no rotation of a certain model is needed. This can save a tremendous amount of time when complex models and rendering are involved. The assets from illustrator were also going to be used when creating the game in Unity. Using 2D files in Unity significantly decreases the size of the output file and the loading time required to initiate the game.

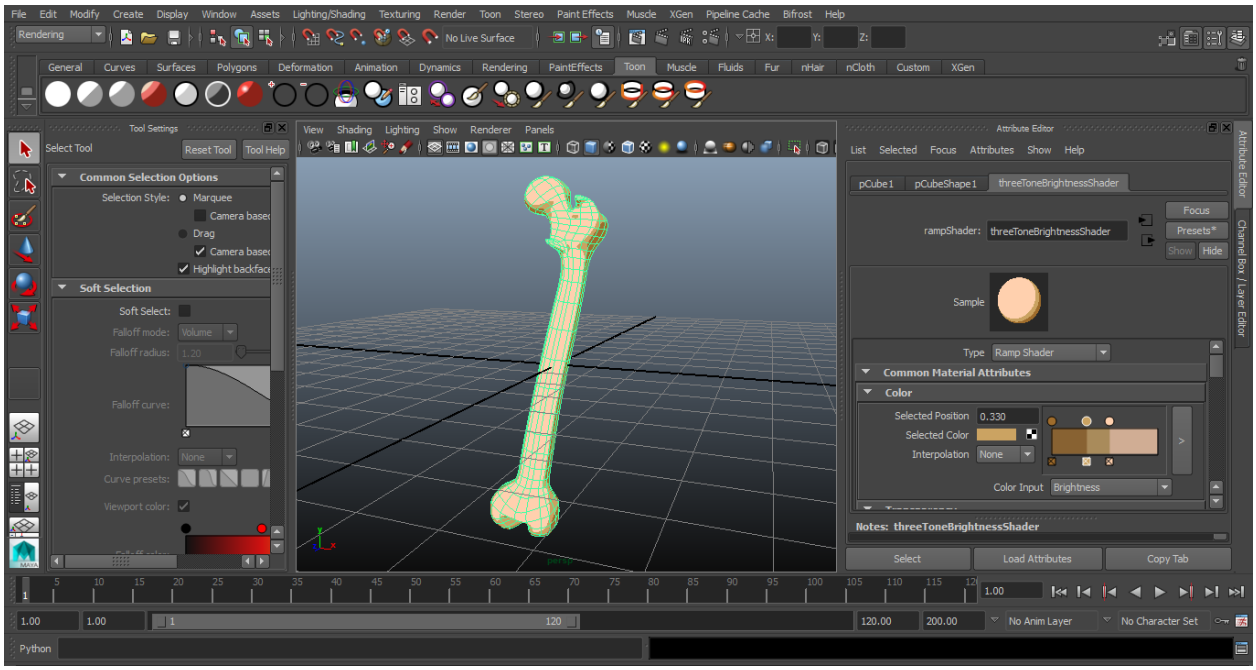


Figure 2. Modeling in Maya, toonshader applied to the femur

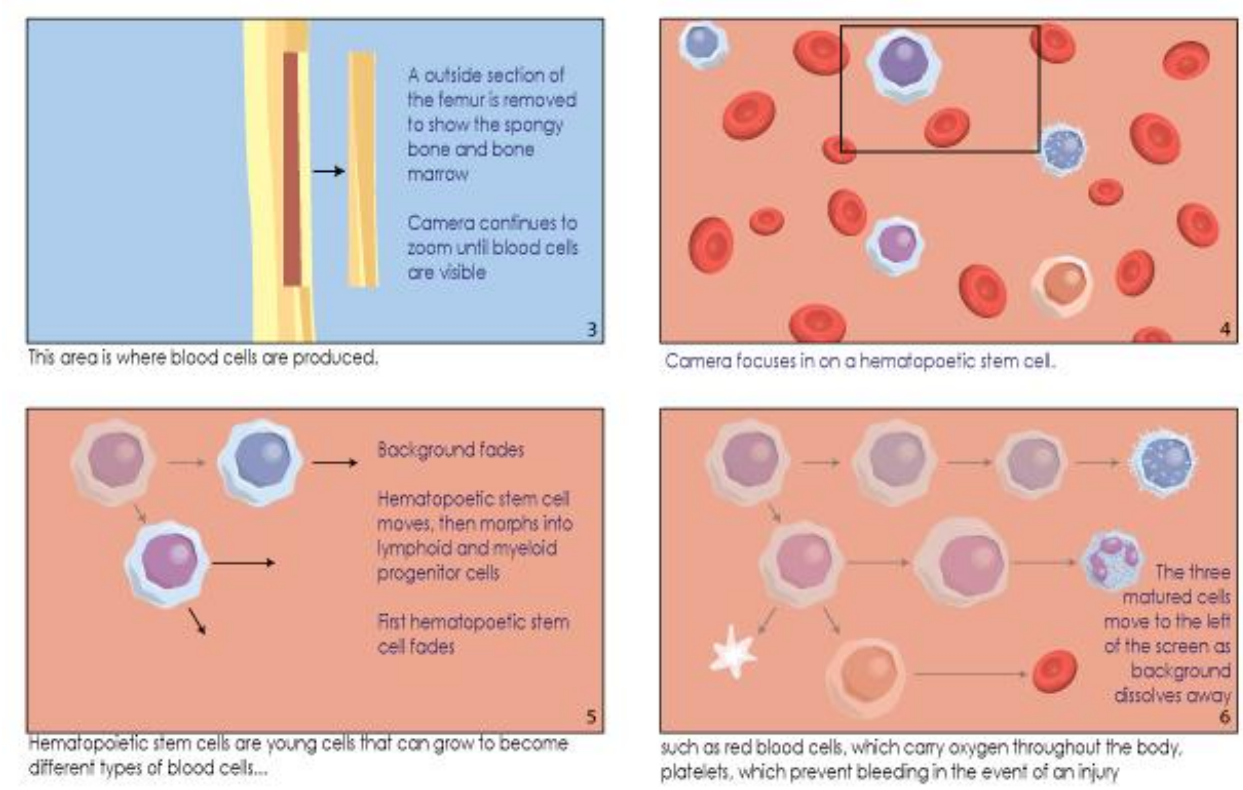


Figure 3. Storyboard samples.

Once the storyboards were approved by the content advisor, Dr. Angela Punnett from SickKids Hospital, an animatic was created to gain a sense of the timing between the narration and the visuals. Illustrator assets were imported into Adobe After Effects and the motion was added there. The overall clarity and accuracy was evaluated and adjusted in the final storyboards.

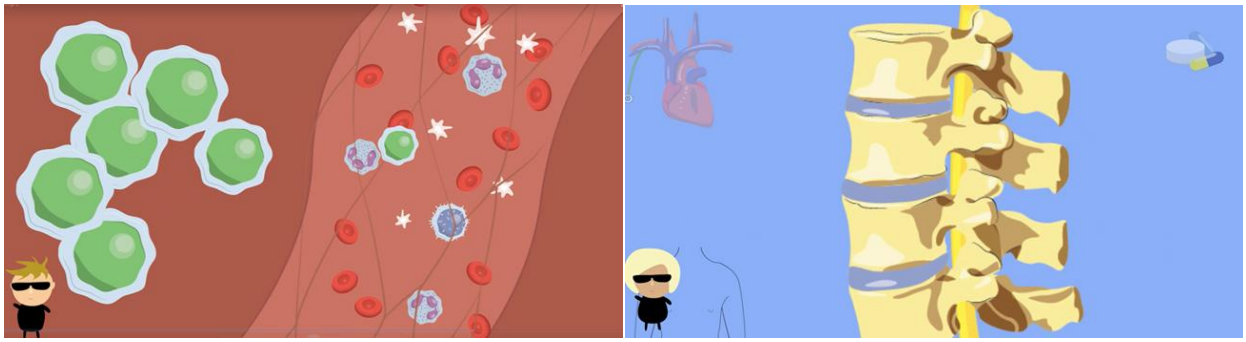


Figure 4.Animatic samples.

Once the final revisions were completed in the storyboards, models in Maya were animated using traditional animation techniques (i.e., Key framing) as well as particles and dynamics. Lighting and shadows were adjusted to give a believable representation of the toon objects. The chemotherapy agent characters were developed entirely in Illustrator and rigged in After Effects using the plug-in Duik. The vector assets and the Maya rendered files were composited together in After Effects on backgrounds of similar color to create consistency in the overall animation.

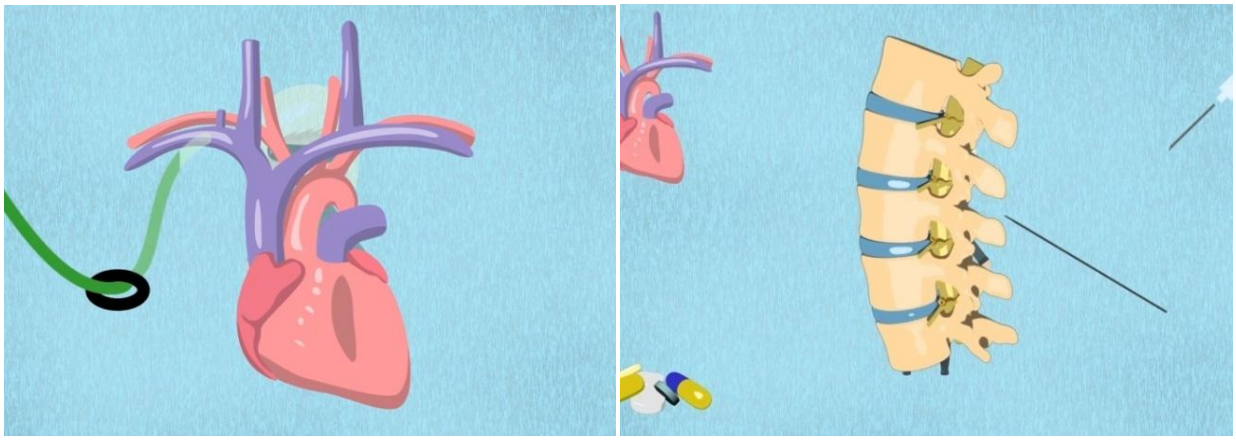


Figure 5. Left: Vector heart asset created in Illustrator. Only the anterior view of the heart was needed to show the chemotherapy being injected into the right subclavian vein. Right: Maya rendered lumbar vertebrae. An 180-degree view was needed to show the placement of the vertebrae in the body as well as the lateral and superior view of the lumbar puncture.

Game Design

The visual aspects of the game follow those of the animation. Scenes in the animation follow through into the game so the viewer can understand where they are located in the body without an introduction or an overview. The same vector assets from the animations were imported into Unity and the game is built using C# coding.

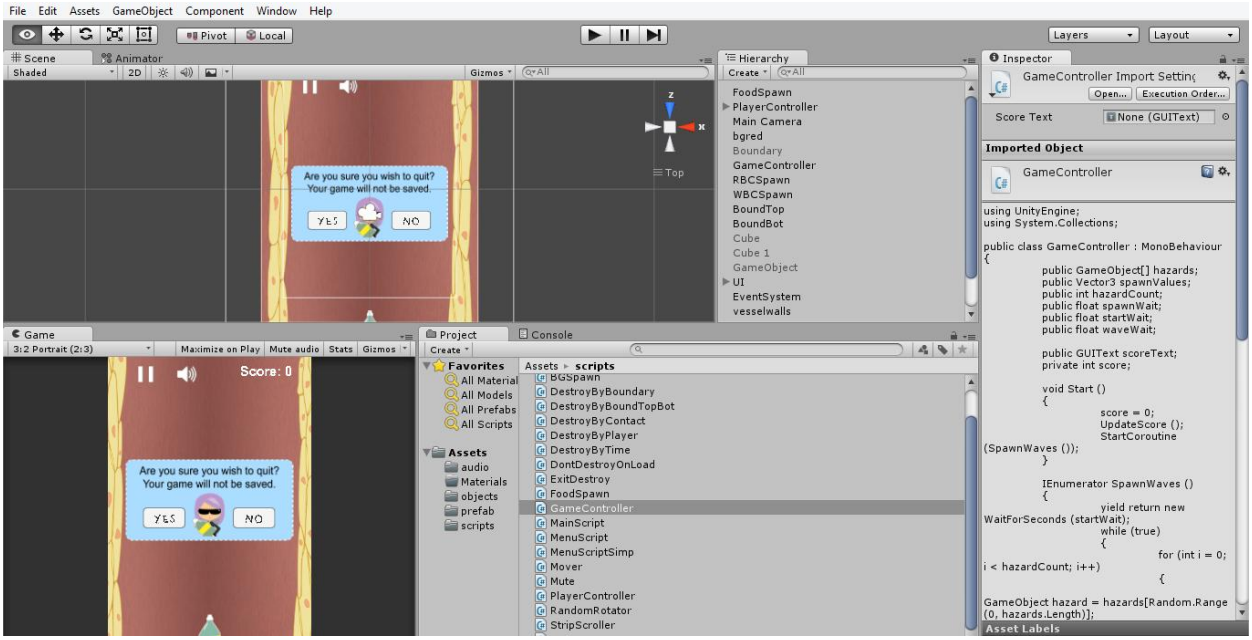


Figure 6. Unity workflow

App Design

The visual interface design went through many ideas. The blue was decided to be the "ALLRecovery color" and was incorporated as the main color through the design process. The first design contained too much writing and was better as a web module instead of an interface seen on a mobile device. The second design was slightly abstract, while it may be considered more "fun", it was decided that an organized design would better suit the app. The final interface design consists of block colors and large touch buttons to allow the viewer to easily follow the navigation system.

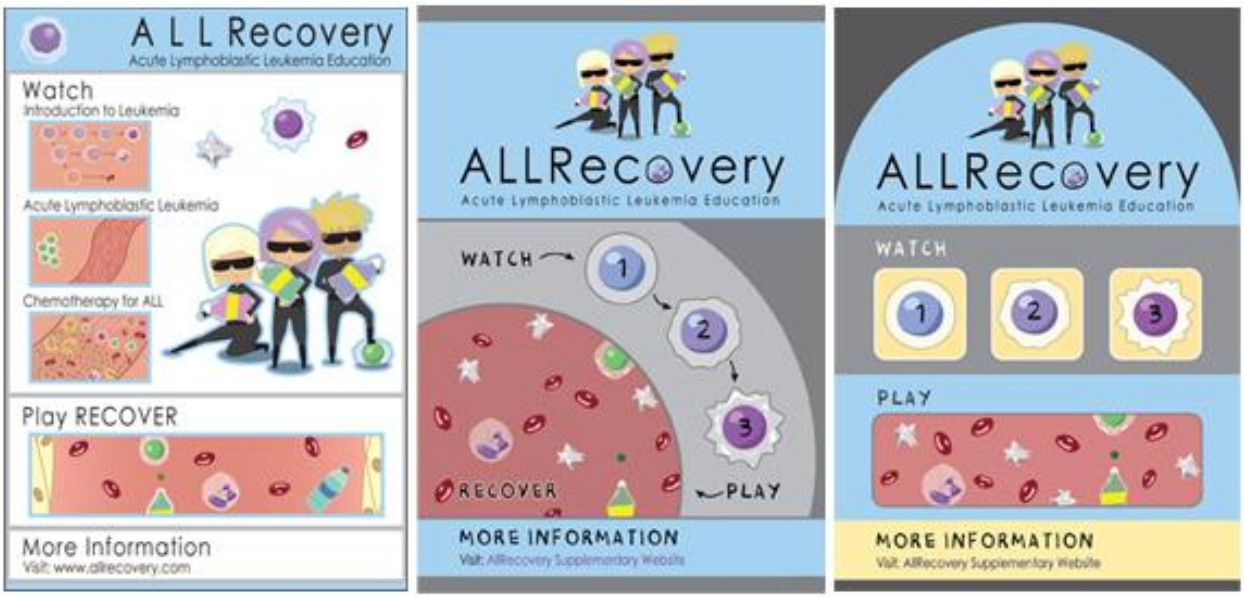


Figure 7.Left: The original ALLRecovery interface design. Middle: An alternate interface design. Right: The final interface design.

Usability Testing and Feedback

Experimental Group

Due to the timing of the usability testing, I was unable to recruit a group of participants directly affected by Acute Lymphoblastic Leukemia. The app was presented to 10 volunteers for 20 minute viewing sessions followed by a short 5 minute interview. Three of the participants were children under the age of 12 and the other 7 were adults ages 24-56. This was a good representation of the audience that ALLRecovery was intended for. Three of the participants had a scientific background.

Experimental Results

The participants who had never heard of ALL found that ALLRecovery was a friendly learning source and were able to reiterate the key terminology and concepts described in the animation and were

also able to explain how ALL is developed. The children expressed a lot of interest in the game and enjoyed the idea of the secret agents. A positive response was seen in all of the participants.

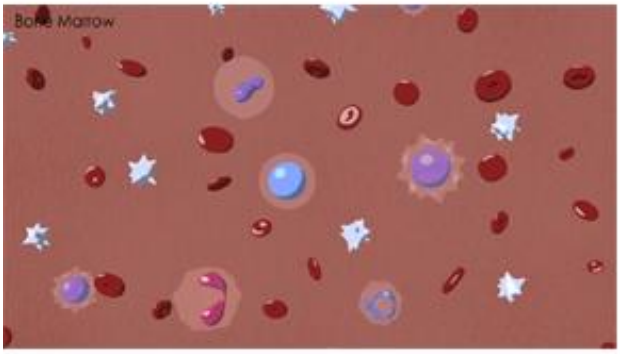
CONCLUSION

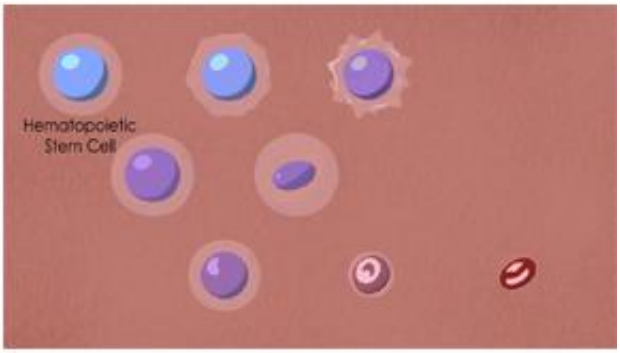
Overall, the final product of ALLRecovery met most of the goals that were set at the beginning of the project. I am content with the results and am happy with what I have learned from this project. The usability testing proved that ALLRecovery was a success and the feedback from the content supervisor was positive as well. I believe that the app has only scratched the surface in terms of what Unity and interactive learning can accomplish. I would like to further explore this side of the medical illustration field in the future.

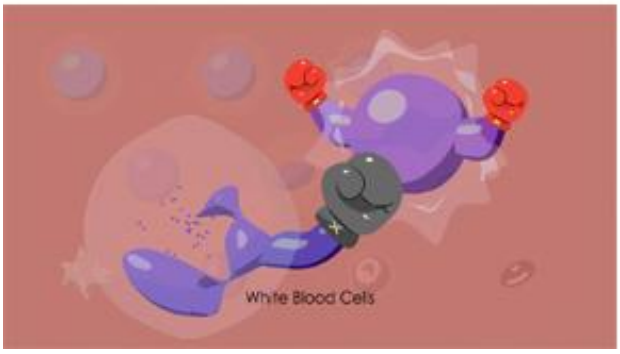
Future work relating to ALLRecovery would be to test the app in a group of patients from SickKids Hospital and gain feedback from patients suffering from ALL and understand their emotions after viewing the app. I would also like to create apps for other types of leukemia and explain the concept in a similar fashion.

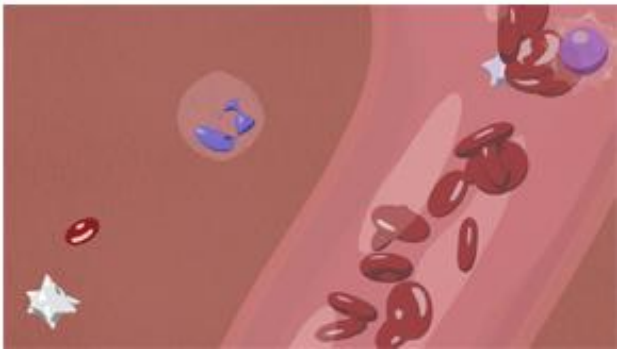
ILLUSTRATIONS

Animations - Part 1: About the blood

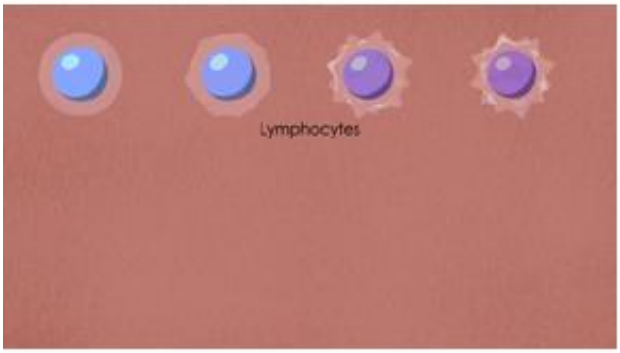


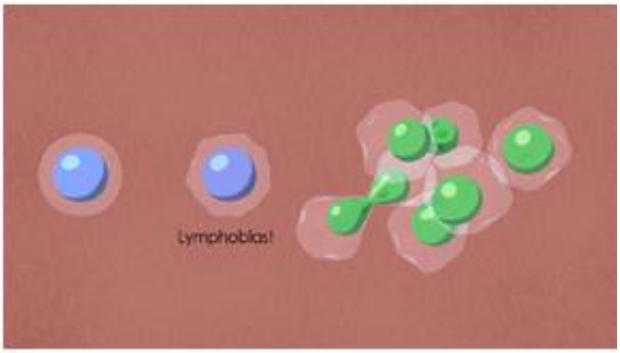


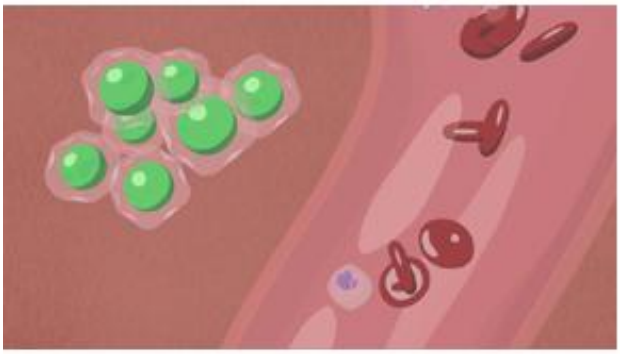


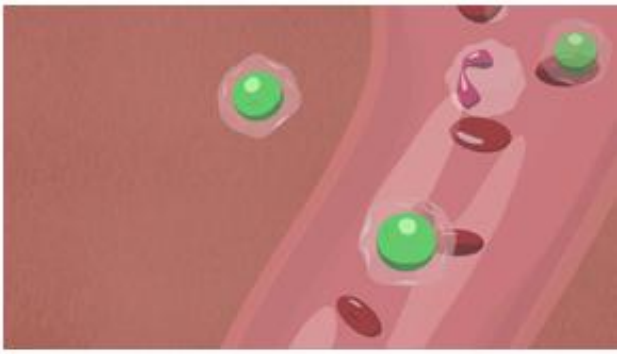


Animations - Part 2: Acute Lymphoblastic Leukemia

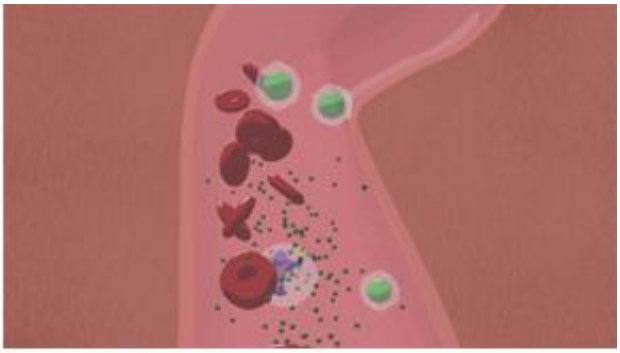


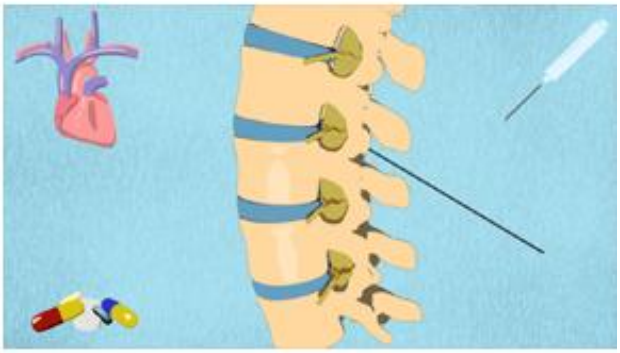


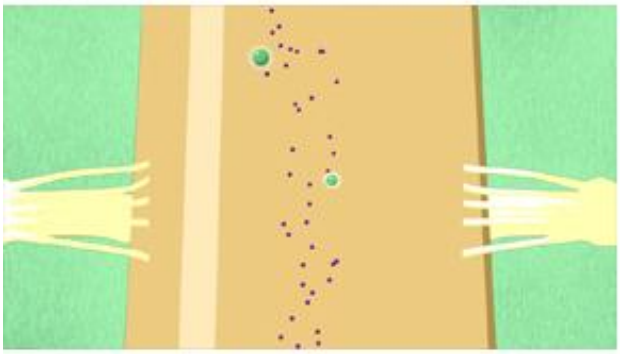


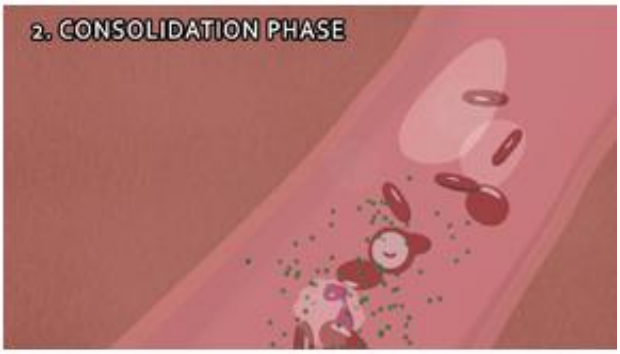


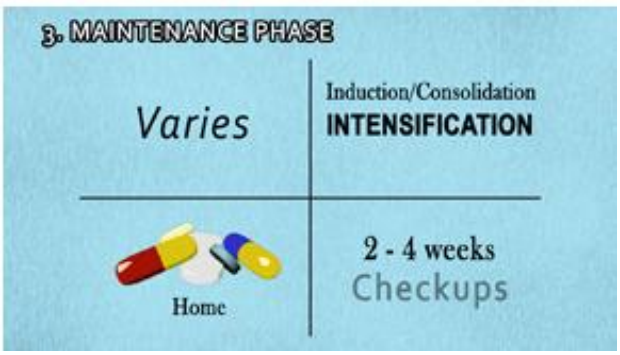
Animations - Part 3: Chemotherapy for ALL



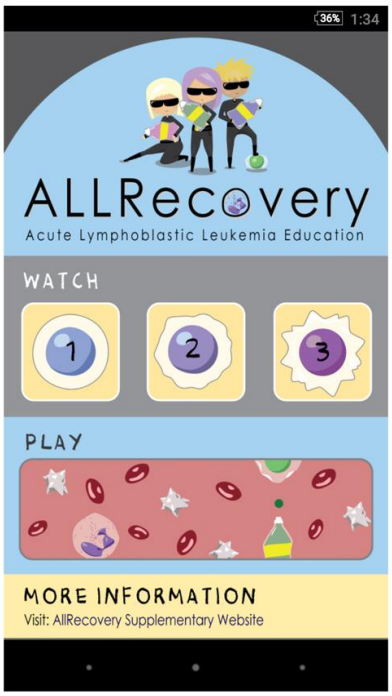


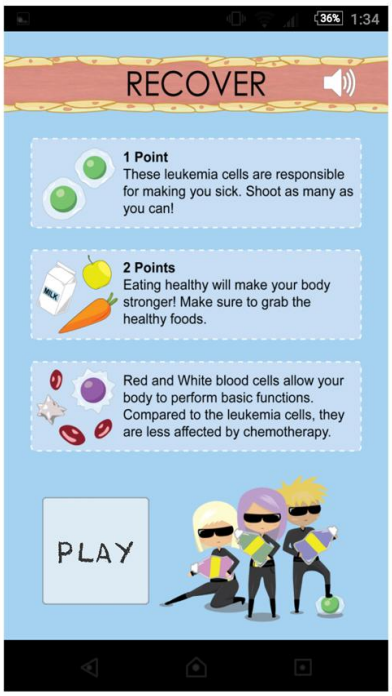


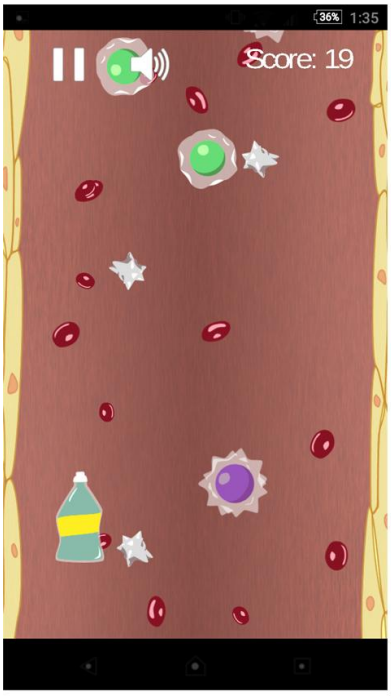


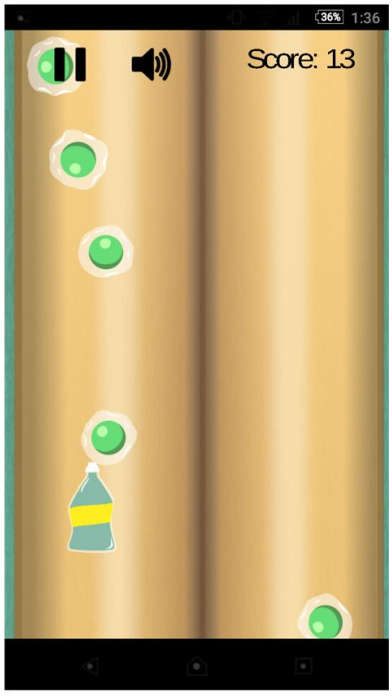


RECOVER for mobile









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